Claims

1.-34. (cancelled)

35. (original) A method for providing a time-of-arrival estimate of a data signal at a receiver, said method comprising:

receiving said data signal;

demodulating said signal;

decoding said signal to form a decoded signal;

optionally selecting a correlation function for said decoded signal if said data signal is not encoded for time stamping; and

estimating said time-of-arrival using said correlation function.

36. (original) The method of claim 35 further comprising determining if said data signal is encoded for time stamping.

37. (original) The method of claim 35 further comprising transmitting said data signal from a wireless asset.

38. (original) The method of claim 37 wherein said transmitting comprises generating a communication sequence corresponding to a preselected reference signal selected for determining said time-of-arrival estimate.

39. (original) The method of claim 38 wherein said generating comprises generating a sequence of at least two consecutive identical symbols.

40. (original) The method of claim 39 wherein:

said generating a sequence of at least two consecutive identical symbols comprises generating a sequence of chipping codes.

41. (original) The method of claim 36 wherein:

said optionally selecting a correlation function comprises selecting a reference sequence; and

said correlation function depends on said reference sequence.

42. (original) The method of claim 41 wherein, when said decoded signal comprises a preselected time-of-arrival estimation sequence, said selecting a reference signal comprises identifying a preselected reference sequence.

43. (original) The method of claim 42 further comprising:

storing a representation of said decoded signal in a buffer;

wherein said estimating comprises correlating said preselected reference sequence with said representation.

44. (original) The method of claim 41 wherein said selecting a reference sequence comprises applying a rule to said decoded signal to select said sequence.

45. (original) The method of claim 44 wherein said applying comprises identifying in said decoded signal a communication sequence corresponding to at least one of a plurality of stored reference sequences.

46. (original) The method of claim 44 further comprising:

storing a representation of said decoded signal in a buffer;

wherein said estimating comprises correlating said reference sequence with said representation.

47. (original) The method of claim 45 wherein said identifying comprises identifying in said decoded signal a communication sequence selected from the group:

(a) a single Barker code sequence;

(b) a series of Barker code sequences;

(c) a series of identical Barker code sequences;

(d) a single PN code;

(e) a series of PN codes;

(f) a series of identical PN codes; and

(g) a combination of any of a-f.

48. (original) The method of claim 41 wherein said optionally selecting a reference sequence comprises selecting a reference sequence selected from the group:

(a) a single Barker code sequence;

(b) a series of Barker code sequences;

(c) a series of identical Barker code sequences;

(d) a single PN code;

(e) a series of PN codes;

(f) a series of identical PN codes; and

(g) a combination of any of a-f.

49. (original) The method of claim 35 wherein said estimating comprises:

evaluating said function using said data signal and a reference sequence; and

determining at least one time-of-arrival estimator value using said function.

50. (original) The method of claim 49 wherein said determining comprises calculating an average of said at least one time-of-arrival estimator value.

51. (original) The method of claim 50 further comprising setting said time-of-arrival equal to said average.

52. (original) The method of claim 49 wherein said determining comprises computing an extreme value.

53. (original) The method of claim 52 wherein said computing comprises computing a quantity selected from the group:

(a) a substantially maximum value; and

(b) a substantially minimum value.

54. (original) The method of claim 49 further comprising determining a time value corresponding to said time-of-arrival estimator value.

55. (original) The method of claim 49 further comprising calculating a time value corresponding to said time-of-arrival estimator value using a time selected from the group:

(a) an access point clock time; and

(b) a network clock time.

56. (original) The method of claim 35 wherein said estimating comprises separating multipath components from line of sight signal components in a correlation signal corresponding to said correlation function.

57. (original) The method of claim 56 wherein said separating comprises detecting a leading edge of a peak in said correlation signal.

58. (original) The method of claim 56 wherein said separating comprises performing channel estimation.

59. (original) The method of claim 35 further comprising optionally selecting a correlation function for said decoded signal if said data signal is encoded for time stamping.

60. (original) The method of claim 59 further comprising identifying a communication sequence in said decoded signal, said communication sequence selected from the group:

(a) a single Barker code sequence;

(b) a series of Barker code sequences;

(c) a series of identical Barker code sequences;

(d) a single PN code;

(e) a series of PN codes;

(f) a series of identical PN codes;

(g) a combination of any of a-f;

(h) a single CCK symbol;

(i) a series of CCK symbols;

(j) a series of identical CCK symbols;

(k) a single PBCC symbol;

(l) a series of PBCC symbols;

(m)a series of identical PBCC symbols;

(n) a single OFDM symbol;

(o) a series of OFDM symbols;

(p) a series of identical OFDM symbols;

(q) a combination of any of h-p.

61. (original) The method of claim 59 wherein said estimating comprises selecting a reference signal selected from the group:

(a) a single Barker code sequence;

(b) a series of Barker code sequences;

(c) a series of identical Barker code sequences;

(d) a single PN code;

(e) a series of PN codes;

(f) a series of identical PN codes;

(g) a combination of any of a-f;

(h) a single CCK symbol;

(i) a series of CCK symbols;

(j) a series of identical CCK symbols;

(k) a single PBCC symbol;

(l) a series of PBCC symbols;

(m)a series of identical PBCC symbols;

(n) a single OFDM symbol;

(o) a series of OFDM symbols;

(p) a series of identical OFDM symbols;

(q) a combination of any of h-p.

62. (Currently Amended) A method for identifying a location of an asset in a communication network, said network having at least a first receiver device and a second receiver device, each receiver device having a known position, said method comprising:

receiving a data signal at each receiver;

demodulating said received signal;

decoding said signal to form a decoded signal;

optionally selecting a correlation function for said decoded signal if said data signal is not encoded for time-stamping;

estimating a first time-of-arrival using said correlation function, said first time-of-arrival corresponding to arrival at said first receiver device of a communication sequence transmitted by said asset;

estimating a second time-of-arrival using said correlation function, said second time-of-arrival corresponding to arrival at said second receiver device of said communication sequence; and

calculating a first time-difference-of-arrivals using said first and second times-of-arrival.

63. (original) The method of claim 62 further comprising optionally selecting a correlation function for said decoded signal if said data signal is not encoded for time-stamping.

64. (original) The method of claim 62 further comprising receiving said communication sequence using said first receiver.

65. (original) The method of claim 62 further comprising receiving said communication signal using said second receiver.

66. (original) The method of claim 62 further comprising selecting said correlation function.

67. (original) The method of claim 66 wherein said selecting comprises using information about said communication sequence to select said correlation function.

68. (original) The method of claim 63 wherein said calculating comprises subtracting said first time-of-arrival from said second time-of-arrival.

69. (original) The method of claim 63 further comprising estimating said location using said first time-difference-of-arrivals.

70. (original) The method of claim 63 wherein said calculating comprises determining a first plurality of asset location solutions.

71. (original) The method of claim 70 wherein, when said network comprises at least one additional receiver device, said estimating further comprises:

determining a second plurality of asset location solutions using said additional receiver device; and

identifying said location using said first and second pluralities of asset location solutions.

72. (original) The method of claim 71 wherein said identifying comprises estimating an intersection of said first plurality and said second plurality.

73. (original) The method of claim 71 wherein said identifying comprises using hyperbolic trilateration.

74. (original) The method of claim 71 wherein said determining a second plurality comprises estimating a distance between said asset and said additional receiver device.

75. (original) The method of claim 74 wherein said estimating comprises calculating a travel time for said communication signal.

76. (original) The method of claim 74 wherein said estimating a distance comprises estimating a signal strength of said communication signal.

77. (original) The method of claim 71 wherein said determining a second plurality comprises calculating a second time-difference-of-arrivals using a third time-of-arrival, said third time-of-arrival corresponding to arrival of said communication signal at said additional receiver, said second time-difference-of-arrivals substantially equal to a difference between said third time-of-arrival and one of said first and second times-of-arrival.

78. (original) The method of claim 71 wherein, when said network comprises at least a third receiver and a fourth receiver, said determining a second plurality comprises calculating a second time-difference-of-arrivals using a third time-of-arrival and a fourth time-of-arrival, said third time-of-arrival corresponding to arrival of said communication signal at said third receiver, said fourth time-of-arrival corresponding to arrival of said communication signal at said fourth receiver, said second time-difference-of-arrivals substantially equal to a difference between said third and fourth times-of-arrival.

79. (original) A method for identifying a location of an asset in a communication network, said network having a first receiver device and a second receiver device, each receiver device having a known position, said method comprising:

estimating more than one first time-of-arrival estimator value using a correlation function, said first time-of-arrival estimator value

corresponding to arrival at said first station of a communication signal from said asset;

estimating more than one second time-of-arrival estimator value using said correlation function, said second time-of-arrival estimator value corresponding to arrival of said communication signal at said second station;

calculating a time-difference-of arrivals using said first and second time-of-arrival estimators.

80. (original) The method of claim 79 wherein said calculating comprises:

for each second time-of-arrival estimator value that corresponds to one first time-of-arrival estimator value, quantifying a difference between said second time-of-arrival estimator value and said first time-of-arrival estimator value; and

if at least two differences are quantified, averaging said differences.

81. (original) The method of claim 79 wherein said averaging comprises setting said time-difference-of arrivals equal to an average of said first and second time-of-arrival estimator values.

82. (original) The method of claim 79 further comprising:

receiving said communication signal using said first receiver; and

receiving said communication signal using said second receiver.

83. (original) The method of claim 79 further comprising selecting said correlation function.

84. (original) A method for identifying a location of an asset in a communication network, said network having at least three receivers, said method comprising:

decoding a data signal from said asset to form a decoded signal;

determining if said decoded signal is encoded for time-stamping;

selecting a correlation function for estimating a time-of-arrival of a communication sequence at said receivers;

collecting at least one time-of-arrival estimate for each of said receivers, said estimate corresponding to a time-of-arrival of said communication sequence at a respective one of said receivers;

calculating a difference for each of at least two pairs of said estimates; and

estimating said location using said differences.

85. (original) The method of claim 84 wherein said estimating comprises defining at least one asset location solution set for each difference.

86. (original) The method of claim 84 wherein said estimating further comprises:

setting at least one solution set criterion; and

discarding a solution set that does not satisfy said criterion.

87. (original) The method of claim 86 wherein said solution set criterion is based on a geometric feature of said network.

88. (original) The method of claim 86 wherein said solution set criterion is based on an index of precision of a time-of-arrival estimate.

89. (original) The method of claim 85 wherein said estimating further comprises finding the maximum likelihood estimator of said location using said solution sets.

90. (original) The method of claim 89 further comprising weighting each time-of-arrival estimate in proportion to an index of precision of the estimate.

91. (original) The method of claim 85 wherein said estimating further comprises finding the least squares estimate of said location using said solution sets.

92. (original) A method for identifying a location of an asset in a communication network, said network having at least a first receiver device and a second receiver device, each receiver device having a known position, said method comprising:

estimating a first time-of-arrival of an 802.11 communication sequence transmitted by said asset, said first time-of-arrival corresponding to arrival of said sequence at said first receiver device;

estimating a second time-of-arrival of said sequence, said second time-of-arrival corresponding to arrival of said sequence at said second receiver device; and

calculating a first time-difference-of-arrivals using said first and second times-of-arrival.

93. (original) The method of claim 92 further comprising receiving said communication sequence using said first receiver.

94. (original) The method of claim 92 further comprising receiving said communication signal using said second receiver.

95. (original) The method of claim 92 wherein said calculating comprises subtracting said first time-of-arrival from said second time-of-arrival.

96. (original) The method of claim 92 further comprising estimating said location using said first time-difference-of-arrivals.

97. (original) The method of claim 92 wherein said estimating comprises determining a first plurality of location solutions for said asset.

98. (original) The method of claim 97 wherein, when said network comprises at least one additional receiver device, said estimating further comprises:

determining a second plurality of asset location solutions using said additional receiver device; and

identifying said location using said first and second pluralities of asset location solutions.

99. (original) The method of claim 98 wherein said identifying comprises estimating an intersection of said first plurality and said second plurality.

100. (original) The method of claim 98 wherein said identifying comprises using hyperbolic trilateration.

101. (original) The method of claim 98 wherein said determining a second plurality comprises estimating a distance between said asset and said additional receiver device.

102. (original) The method of claim 101 wherein said estimating comprises calculating a travel time for said communication signal.

103. (original) The method of claim 101 wherein said estimating a distance comprises estimating a signal strength of said communication signal.

104. (original) The method of claim 98 wherein said determining a second plurality comprises calculating a second time-difference-of-arrivals using a third time-of-arrival, said third time-of-arrival corresponding to arrival of said communication signal at said additional receiver, said second time-difference-of-arrivals substantially equal to a difference between said third time-of-arrival and one of said first and second times-of-arrival.

105. (original) The method of claim 98 wherein, when said network comprises at least a third receiver and a fourth receiver, said determining a second plurality comprises calculating a second time-difference-of-arrivals using a third time-of-arrival and a fourth time-of-arrival, said third time-of-arrival corresponding to arrival of said communication signal at said third receiver, said fourth time-of-arrival corresponding to arrival of said communication signal at said fourth receiver, said second time-difference-of-arrivals substantially equal to a difference between said third and fourth times-of-arrival.

106. (original) A method for identifying a location of an asset in a communication network, said network having a first receiver device and a second receiver device, each receiver device having a known position, said method comprising:

estimating more than one first time-of-arrival estimator value, said first time-of-arrival estimator value corresponding to arrival at said first station of an 802.11 communication signal from said asset;

estimating more than one second time-of-arrival estimator value, said second time-of-arrival estimator value corresponding to arrival of said communication signal at said second station;

calculating a time-difference-of arrivals using said first and second time-of-arrival estimators.

107. (original) The method of claim 106 wherein said calculating comprises:

for each second time-of-arrival estimator value that corresponds to one first time-of-arrival estimator value, quantifying a difference between said second time-of-arrival estimator value and said first time-of-arrival estimator value; and

if at least two differences are quantified, averaging said differences.

108. (original) The method of claim 106 wherein said averaging comprises setting said time-difference-of arrivals equal to an average of said first and second time-of-arrival estimator values.

109. (original) The method of claim 106 further comprising:

receiving said communication signal using said first receiver; and

receiving said communication signal using said second receiver.

110. (original) The method of claim 106 further comprising selecting a correlation function.

111. (original) A method for identifying a location of an asset in a communication network, said network having at least three receivers, said method comprising:

estimating a time-of-arrival of an 802.11 communication sequence at said receivers;

collecting at least one time-of-arrival estimate for each of said receivers, said estimate corresponding to a time-of-arrival of said communication sequence at a respective one of said receivers;

calculating a difference for each of at least two pairs of said estimates; and

estimating said location using said differences.

112. (original) The method of claim 111 wherein said estimating comprises defining at least one asset location solution set for each difference.

113. (original) The method of claim 111 wherein said estimating further comprises:

setting at least one solution set criterion; and

discarding a solution set that does not satisfy said criterion.

114. (original) The method of claim 113 wherein said solution set criterion is based on a geometric feature of said network.

115. (original) The method of claim 113 wherein said solution set criterion is based on an index of precision of a time-of-arrival estimate.

116. (original) The method of claim 112 wherein said estimating further comprises finding the maximum likelihood estimator of said location using said solution sets.

117. (original) The method of claim 116 further comprising weighting each time-of-arrival estimate in proportion to an index of precision of the estimate.

118. (original) The method of claim 112 wherein said estimating further comprises finding the least squares estimate of said location using said solution sets.